2. FARMING SUSTAINABILITY—INTERACTIONS OF ECONOMIC, ENVIRONMENTAL AND SOCIAL DIMENSIONS

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Abstract

The conviction that farm development depends not only on the economic dimension but also on the environment as well as the social dimension, is increasingly widespread. The purpose of this study was to assess the interaction between the economic, social and environmental fields of agricultural activity and to identify cause-and-effect relationships between the aforementioned dimensions on the basis of family farms in Wielkopolska. The study was based on a literature review and the results of surveys conducted among 120 farms in the Wielkopolska region of Poland. Having applied structural equation modelling analysis, the authors discovered that there are significant mutual positive relations between the economic, social and environmental spheres in the analysed farms. Thus, those relationships can be complementary to each other. The presented research indicates the need to always consider agriculture as a broad and complex economic, social and environmental system, as the European Union already does, and to adjust policies according to the region's peculiarities and its unique features. Simultaneously, one should aim to achieve multiple and diversified goals in agriculture.

Keywords: sustainability, farming, European Union, environment, low carbon.

JEL codes: Q01, Q12, Q56.

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Introduction

As the issues related to sustainability are more and more relevant in everyday life, they resonate particularly strongly in modern economics. The already theoretically established paradigm of sustainable development (Czyżewski & Kułyk, 2013; Zegar, 2007, 2018), placed between mainstream and heterodox economics, which assumes the dynamic achievement of harmony between economic, social and environmental dimensions—as practice shows—is not easy to achieve at different levels. The pursuit of sustainability reveals the need to take into account in economic studies full external costs and benefits, including the environmental ones, towards the compatibility of the microeconomic and social optimum. Thus, it is problematic to reconcile microeconomic efficiency, aimed primarily at satisfying the needs of the individual, with macroeconomic rationality, where community-wide, national interests are more important (Kulawik, 2007; Van Huylenbroeck et al., 2004). It is troublesome to raise economic efficiency, where economic results are the key, while achieving social equity, where the individual is the focus (Krasowicz, 2009; Krysztofiak & Pawlak, 2017; Pimentel, 2006; Tarnowska, 2010). At the same time, these socio-economic processes are embedded in the environment, with which there is a feedback loop usually manifested in negative environmental externalities.

These phenomena also relate to the agricultural sector, where there are interactions between the aforementioned areas, i.e. economic, social and environmental. In the light of the paradigm of sustainable development, it is desirable to harmoniously achieve the three key dimensions, but the practice embedded in the industrial, microeconomic, purely market-based approach indicates that in economic activity, economic issues most often take the lead, with social issues receding into the background, and the greatest cost is borne by the environment. However, modern economics sees an increasing need to integrate the aforementioned areas and strengthen positive interactions between them, because there is a conviction that the final, broad profit and loss account that internalises social and environmental issues will prove more beneficial in the long run.

Thus, the purpose of the study was to assess the interaction between the economic, social and environmental dimensions of agricultural activity and to identify cause-and-effect relationships between the aforementioned orders, using the example of family farms in Wielkopolska. Despite the above-mentioned difficulties associated with the effort to make farms sustainable, we want to show that it is possible to simultaneously achieve the economic and social order, together with the environmental order.

2.1. Literature review

The agricultural sector faces a number of problems, with increasing requirements being placed on farmers. They should produce while respecting soil, water resources, the atmosphere and biodiversity (Kleijn et al., 2009; Matson et al., 1997; Tilman et al., 2001; Tscharntke et al., 2005), and at the same time, their activities should be profitable so that the farmer's family may live with dignity and the farm can develop. Moreover, food security in terms of physical and economic availability of food and its quality also largely depends on them. It should be noted, however, that it is difficult to reconcile the provision of food security and income for food producers with the preservation of the natural environment, where constraints, resulting from this environment, force the restoration of disturbed equilibriums so that agriculture, or existence, can continue (Matuszczak, 2020). The symptoms of disharmony in the economic, social and environmental order in agriculture are manifold, including the inability of agricultural income to keep up with increases in agricultural labour productivity (efficiency) and increasing pressure to create public goods in rural areas threatened by environmental and climate destruction. One of the reasons for this is the mechanism of technological treadmill, which forces further industrial development of agriculture (Chen et al., 2011; Czyżewski, 2017; Levins & Cochrane, 1996). Under these conditions, while agricultural income is growing, it does not keep up with the growth of income in non-agricultural sectors. This income disparity is accompanied by social deprivation of farmers. As a result, agricultural production structures are changing, but some space for environmental action is also created. This is because the need for the supply of environmental public goods emerges (OECD, 2015; Viaggi et al., 2021; Villanueva et al., 2014; Westhoek et al., 2013). Thus, the rationale for clarification and implementation of a model of sustainable development of agriculture arises. Under these conditions, it becomes necessary to strive for sustainable development of farms, where, on the one hand, care is taken to pay for the involvement of their own productive factors (labour, land and capital) in the operational activities of the farm and payment for the risks taken by the farmer, i.e. *de facto* income, including education, and on the other hand, the inputs that constitute the factors creating environmental pressure in agricultural activities are monitored so that the relationship can be maximised.

In the literature, we can find positive examples indicating that family farming makes an important contribution to the sustainability of the sector, as there are positive interactions between the socio-economic aspects, while at the same time being more concerned about the use of natural resources and focusing on practices that respect the environment (Bosc et al., 2013; Piedra-Muñoz et al., 2016). Family farms "are the best hope for a sustainable future for agriculture and for humanity," but this requires achieving harmony between the environmental, social and economic perspectives of sustainability (Ikerd, 2013; Pretty, 2008; Saifi & Drake, 2008; United Nations, 2015).

However, despite the consensus that it should be harmonious to achieve the three orders, it is not common to analyse the interactions between them. An attempt to do so can be found in the work of Rajaram and Das (2010) who suggested using a "fuzzy rule approach" to model the interactions of sustainability components in an agroecosystem. The need to analyse the relationships between the dimensions of sustainability was also pointed out by the European Commission (2001). Interdependencies and interactions between the different orders were pointed out by Galdeano-Gómez et al. (2012, 2017), who used the example of the Almeria region (Spain), as well as between the social and economic dimensions in that region presented by Torres et al. (2016). Other studies point to the links between sustainability (understood in terms of socio-economic characteristics, environmentally friendly practices and innovation) and profitability, indicating that harmonised elements of sustainability promote higher farm profitability (Piedra-Muñoz et al., 2016).

This research contributes to the above-mentioned discussion by showing the relationship between the environmental, economic and social dimensions of agricultural activity, on the example of farms from Wielkopolska. In this work, low carbon is a development (deepening) of the environmental dimension due to the increasing importance of climate issues within the environment. Examples of research results (Li et al., 2016) suggest that decreasing energy intensity in agriculture is the main factor behind declines in CO_2 emissions, and increasing energy efficiency is a more effective mean to reduce CO_2 emissions than changes in the fuel-mix. Furthermore, France, Finland, Sweden, Denmark, the Netherlands, Poland and Belgium have the highest potential for reduction in CO_2 emissions in agriculture.

2.2. Material and methods

To analyse various interactions between farming dimensions we used structural equation modelling (SEM). This advanced technique is considered to be a very good and effective way for analysing interdisciplinary issues within sustainable development or environmental economics (Brown, 2015; Hooper et al., 2008). Therefore, it could be employed in our project where we discovered relationships between economic, social and environmental fields of farming. Modelling of structural equation allows us to combine the advantages of analysis of variance, regression and factor analysis, extending them with the possibility of modelling cause-and-effect relationships using latent variables (Garson, 2015; OECD, 2008). In our study, latent variables are economic, social and environmental performances of farms. While using SEM, we can identify indirect, direct and total independencies between variables—both latent (construct) and observed variables (Garson, 2015; Anghel et al., 2019). A huge advantage of SEM is the possibility to add relationships between different variables, which allows us to make to model more complex systems of interactions between variables. Broad descriptions of SEM, with its many different types and advantages, are presented by Garson (2015), Hoyle (2012) and StataCorp (2017).

In the presented research, the results of a survey conducted in 2020, focusing on 120 agricultural holdings from the Wielkopolska region were used. These holdings are part of the farm accountancy data network (FADN). The holdings were divided proportionally based on both the type of farming (TF) and the economic size of the farms (ES). The selection of units for the study was purposive-random, aiming to capture a diverse range of participants. An interview questionnaire titled "Assets and income in agricultural holdings in the paradigm of sustainable development" was used as a research tool (Grzelak, 2019). The interviewers assigned to the selected farms were advisors from the Agricultural Advisory Centre, contributing to the collection of highly reliable research material. Throughout the survey, only in a few instances (nine cases), was there a need for the questionnaires to be supplemented with explanations from the interviewers. This occurred particularly in situations involving outlier observations, where additional information was required.

2.3. Results and discussion[1]

During the analysis of the data, multiple models were developed to explore the interactions between economic, social and environmental variables related to family farms in the Wielkopolska region of Poland. Structural equation modelling was used to analyse the data. The most favourable model, as illustrated in Table 2.1, was selected for presentation. As depicted, each latent variable representing the three dimensions of sustainability was constructed using a set of original variables. In the economic pillar, we included positive determinants such as agricultural output, agricultural income and land value, while the negative indicator was represented by the sale of products from the farm without any contracts (*ad hoc*). Regarding the environmental dimension, the positive factors consisted of maintaining grassland on the farm and implementing a fertiliser plan, while the negative influence was associated with a high proportion of cereals in the crop structure. Within the social domain, the positive drivers were a significant share of agricultural income in the household's total income and having agricultural education, while the negative

[1] Collecting data for the research was financed by the National Science Centre in Poland (grant no. 2018/29/B/HS4/01844).

determinant was a high percentage of expenditure on food in the household's total expenditure. This comprehensive model provides a holistic understanding of the integration among the analysed farms, showcasing their ability to excel simultaneously in economic, social and environmental aspects. Consequently, no conflicts arise, such as those between economic and environmental activities or between economic and social performance, within the investigated Polish farms.

Table 2.1. Dimensions of farming within the sustainability concept and their determinants in family farms from the Wielkopolska region, Poland

<table>
<tr><th>Economic (latent variable)</th><th>Environmental
(latent variable)</th><th>Social
(latent variable)</th></tr>
<tr><td>x_1: Value of agricultural output given in EUR</td><td>x_5: The area of grassland in hectares</td><td>x_8: Share of agricultural income in the household's total income (0–100%)</td></tr>
<tr><td>x_2: Land value given in thousands EUR</td><td>x_6: Does the farm have a fertilising plan (1 = yes; 0 = no)?</td><td>x_9: Type of education (1 = agricultural education; 0 = non-agricultural education)</td></tr>
<tr><td>x_3: Agricultural income given in thousands EUR</td><td rowspan="2">x_7: Share of cereals in the structure of crops (0–100%)</td><td rowspan="2">x_{10}: Share of expenditure on food in the household's total expenditure (1 = below 10%; 2 = 10–20%; 3 = 20–35%; 4 = 35% and more)</td></tr>
<tr><td>x_4: Type of integration with the market (1 = sale of products without contracts, ad hoc; 0 = other)</td></tr>
<tr><td colspan="3">Main interactions (max. 1):
Economic & environmental: positive (0.54)
Economic & social: positive (0.44)
Environmental & social: positive (0.35)</td></tr>
<tr><td colspan="3">Additional interactions (max. 1):
Land value & grassland: negative (–0.29)
Land value & food expenditure: negative (–0.18)
No contract & food expenditure: positive (0.21)</td></tr>
</table>

Source: based on (Grzelak et al., 2022).

The positive relationships between economic, environmental and social dimensions among farms were confirmed, among others, by Gómez-Limon and Sanchez-Fernandez (2010), Galdeano-Gomez et al. (2017), Haileslassie et al. (2016), Sulewski and Kłoczko-Gajewska (2018). The most common positive interactions seem to occur between the social and economic dimensions; however, the economic-environmental link is gaining more and more importance both at the farm and agricultural sector levels, which is the case due to several facts. In brief, the good environmental condition is necessary for the long-term economic viability.

There is growing concern among farmers and consumers about the state of the environment. Policies (agricultural, climate and energy) require better matching of economic activities to environmental limitations. For this reason, the authors explored the economic and environmental link deeper and in a more detailed form, which made it possible to identify the drivers of low-carbon agriculture among farms in the Wielkopolska region (Table 2.2). Additionally, we aimed to define low-carbon agriculture as a concept and part of a broader idea of a low-carbon economy.

Table 2.2. Low-carbon agriculture and its drivers in family farms from the Wielkopolska region, Poland

<table>
<tr><th>Low-carbon agriculture (latent variable)</th><th>Productivity (latent variable)</th></tr>
<tr><td>Fertiliser use efficiency (the ratio of agricultural output in thou. PLN/fertiliser use in 1000 kg)</td><td>Land productivity (the ratio of agricultural output in thou. PLN/utilised agricultural area in ha)</td></tr>
<tr><td>Fertiliser efficiency (the ratio of agricultural output in thou. PLN/expenditure on fertilisers in thou. PLN)</td><td>Labour productivity (the ratio of agricultural output in PLN/number of person-hours worked on a farm)</td></tr>
<tr><td>Energy efficiency (the ratio of agricultural output in thou. PLN/expenditure on energy in thou. PLN)</td><td rowspan="2">Capital productivity (the ratio of agricultural output in PLN/the value of total assets in PLN)</td></tr>
<tr><td>Thermal insulation of livestock buildings (dummy variable: 1 = yes; 0 = no)</td></tr>
<tr><td colspan="2">Additional variables:
Agricultural income in thou. PLN
Land value in thou. PLN
Share of agricultural income in household’s total income (in %)</td></tr>
<tr><td colspan="2">Main relationships (max. 1):
Impact of productivity on low-carbon agriculture: positive (0.72)
Productivity & income: positive (0.89)
Productivity & share of agricultural income in household’s total income: positive (0.32)</td></tr>
<tr><td colspan="2">Additional interactions (max. 1):
Land productivity & capital productivity: positive (0.32)
Land productivity & low-carbon agriculture: positive (0.49)
Labour productivity & low-carbon agriculture: positive (0.6)
Fertiliser use efficiency & fertiliser efficiency: positive (0.9)</td></tr>
</table>

Source: based on (Borychowski et al., 2022).

Low-carbon agriculture can be defined as an agricultural system which enables efficient production of materials, food, feed and fibres while reducing energy inputs and greenhouse gas emissions from agriculture, following the principles of sustainable development (Piwowar, 2019). It shall be clearly indicated that it is possible to simultaneously achieve both economic and environmental goals (Table 2.2). Our results are consistent with other authors’ findings. Rafiq et al. (2016) confirmed that energy intensity is an important driver of pollution emissions; thus, increasing energy efficiency promotes low-carbon agriculture. Iram et al. (2020) also showed the importance of energy efficiency for environmental performance and carbon emission reduction. Piwowar (2019) additionally specified that improving energy efficiency in Polish agriculture should relate to lowering fuel consumption. Similarly, other authors emphasised the role of increasing fertiliser efficiency in moving towards low-carbon agriculture (Koondhar et al., 2021; Piwowar, 2019)

Conclusions

The research conducted allows to formulate the following conclusions and recommendations:

- There are significant mutual and positive relations between the economic, social and environmental spheres within the analysed farms. Thus, those relationships can be complementary to each other. In practice, this means that to promote sustainability in the social and environmental dimensions, income and capital are needed to finance pro-environmental actions and to improve well-being in the social sphere (better meeting consumption needs, providing education). By supporting one dimension of sustainability, other dimensions can also be improved, assuming the existence of a certain system of environmental and social protection. The strongest positive relationship was observed between the economic and environmental dimensions, which may come as somewhat surprising. It has been noted that the adoption and promotion of best farming techniques, eco-innovation and services which require capital are associated with improving environmental performance (Van Grinsven et al., 2019). This finding is further supported by our research, which indicates that resource productivity plays a crucial role in determining a low-carbon economy within farms. Therefore, qualitative factors such as production techniques and implementation of innovations to create a low-carbon economy hold significant importance for both the environmental and economic dimensions of farms. Within the economic dimension, the value of output and income exhibited the most positive associations, while assets were given relatively less significance. This observation could be attributed to the capitalisation of subsidies in agricultural land prices, influencing the relative importance of assets in the economic dimension. At the current stage of development of the EU countries, the evolution of the CAP support instruments tends to put increased emphasis on the environmental context of the agricultural support mechanism and on developing a low carbon-economy. To achieve this goal, the CAP support should be more closely linked to environmental investments. Green investment grants could support using alternative energy sources (biogas plants, photovoltaics), thermal modernisation of buildings, elimination of old types of furnaces. Thus, there is a need for further increasing the support of the environmental component in the functioning of agricultural holdings. We mean here also building farmers' awareness of these issues through education and training.
- As regards the social dimension of functioning of farms, it is important to further promote the economic and social infrastructure and improve the education of agricultural producers. It results from the fact that the social dimension is economic in nature.

- Climate change will stimulate environmental issues as well as low-carbon economy in the functioning of farms to a greater extent. This may facilitate a balance between the economic, social and environmental fields. Further research in this area should take into account externalities as well as provision of public goods by farms. The results of such research would help to identify other determinants that shape the relationships between the economic, environmental and social dimensions of the sustainability of farms. It would be interesting to conduct similar research in regions with different levels of agricultural development.

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